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MINERALOGIC AND PETROLOGIC STUDIES OF METEORITES AND LUNAR SAMPLES

Grant NGL 09-015-150

FINAL REPORT

1 February 1971 through 31 January 1984

Principal Investigator
Dr. John A. Wood

March 1984

Prepared for
National Aeronautics and Space Administration
Johnson Space Center
Houston, TX 77058

Smithsonian Institution
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The Smithsonian Astrophysical Observatory
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This is the Final Report of research activities carried out by the Extraterrestrial Petrology group at the Smithsonian Astrophysical Observatory, with the support of NASA Grant NGL 09-015-150, in the period February 1, 1971 - January 31, 1984. The Principal Investigator remembers these thirteen years as an exhilarating time of discovery, collaboration, controversy, radical new concepts, and a dramatic reshaping of the prevailing picture of the nature and early evolution of planets.

Our group fluctuated in size from about four to nine people in that time. Until last year, Ursula B. Marvin was my Co-Investigator. A constant thread through ten of the thirteen years has been the indispensable labor of our Research Assistant, Karen Motylewski. NGL 09-015-150 supported ten postdoctoral associates in this time: Abhijit Basu, Michael J. Drake, Marie E. Hallam, Claude T. Herzberg, John B. Reid, Steven M. Richardson, Graham Ryder, Douglas B. Stoeser, G. Jeffrey Taylor, and Robert W. Wolfe. It also supported four Harvard University graduate students: Ronald E. Cohen, Alan S. Kornacki, Gayle E. Lux, and Harry Y. McSween, Jr. McSween and Kornacki have completed their Ph.D. research in this laboratory; Lux and Cohen contributed to the effort, but did not undertake theses. Finally, the grant supported five Harvard undergraduates: Michael B. Baker, Ellen Gitlin, Philip R. Maloney, Julia A. Peck, and Hartley P. Rogers. These are talented and highly motivated young scientists, and I am proud that they wanted to work with me. The reader will recognize the names of several workers who have achieved prominence as independent investigators since they left my group. When the younger group members have had time to mature, there will be more.

When Grant NGL 09-015-150 was initiated in 1971, the group was totally committed to research on the lunar samples that were being collected by the Apollo astronauts on the moon. We had already worked on them for the year and a half since Apollo 11, under NASA Contract NAS 9-8106. In that time we were largely instrumental in making one of the most important discoveries of the Apollo era, namely that the lunar highlands were composed largely of rocks of the anorthositic clan, and that the moon must have been covered by a deep, global magma ocean in earliest times in order to produce an anorthositic crust.

In the remaining years of the Apollo flight program we systematically studied the many rock types that occurred as coarse fragments in the lunar soil samples collected. We inventoried the soils of all six Apollo missions, and also the soils returned by the Soviet missions Luna 16, 20, and 24. This work enlarged on our knowledge of the range and relative abundances of rock types at the lunar surface, and their variation with position on the moon.

In 1973 - 1975 I led, and the group petrographically supported, the "Consortium Indomitabile," which collaboratively studied all the samples collected from Boulder 1, Station 2, Apollo 17. The Consortium completed and published, on schedule, all the studies envisaged by LSAPT, which had organized it. To my knowledge, it was the first of the great many consortia that LSAPT had organized to do so. Subsequently (1975 - 1977) we undertook a second consortium project, the "Imbrium Consortium," but this was less successful. Though my group carried out its petrographic objectives and published a major paper on the variation of composition with depth in the crust, and we published two detailed interim reports of the consortium's work, the level of collaboration and interest generally among consortium members was less than in the case of the Consortium Indomitabile, and we never published a final report.

After 1977 our degree of involvement in lunar science tapered off, as we shifted our emphasis to meteorite studies (where it had been prior to Apollo). At present the component of lunar science is almost zero. I don't intend to ever leave the field, however; there are important and challenging problems still unsolved, and a time will come when we will resume the study of lunar samples.

Our meteorite studies have centered on the properties and apparent origin of the most primitive of known planetary samples, carbonaceous chondrites. We have tried to understand them in the context of the origin of the solar system, and, being located at an Astrophysical Observatory, we have placed special emphasis on the astrophysical perspective. It is my personal feeling that most workers pay too little attention to this essential aspect of the problem.

Briefly stated, our principal meteoritic contributions during the term of this grant have included (1) major studies of the variability of major element compositions among chondrules and Ca,Al-rich inclusions (CAI's); (2) the most detailed and perceptive study to date of the fine-grained CAI's, which are numerically far more abundant than the coarse-grained CAI's that dominate the literature; (3) an independent (of Chicago) consideration of the relationships among CAI types, and a proposed improved classification scheme to reflect these relationships; (4) a recognition that the CAI's are likely to be residues left after masses of presolar solid material were heated and partially volatized rather than simple condensates from the solar nebula (the prevailing view); and (5) the discovery that meteoritic chondrules were probably formed by the heating effect of aerodynamic drag on presolar solids as they plunged into the solar nebula, during the gravitational collapse of interstellar material that formed the solar system.

We have also made systematic studies of the fine-grained matrix material that accompanies chondrules and CAI's in primitive meteorites, and have investigated the effects of planetary hydrothermal alteration of matrix material in the Cl chondrites.

The list of publications that follows includes full-length papers and extended abstracts published during the period of this grant and supported wholly or in part by its funds. No effort has been made to detail the many talks presented by memebers of this group to professional and lay audiences over the past thirteen years.

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